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CLIMATE IN SOUTHEAST ALASKA IN RELATION TO TREE GROWTH

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The characteristics and production of forests are largely governed by climate. Within relatively uniform climatic zones differences in climate are important to tree growth. Isaac has shown that while Douglas-fir (Pseudotsuga menziesii (Mirb.) (Franco) will survive under a wide range of climatic conditions, any one particular strain will produce a profitable timber crop only under a rather limited climatic range. (7)

Information on climate is basic in evaluation of forest research. Such information is of particular significance in development of a seed zone classification and provenance tests. Sitka spruce (Picea sitchensis) /Bong/ Carr) grown from seed collected in Alaska is being planted in Iceland and certain northern European countries and foresters from these countries are vitally interested in obtaining this seed from suitable climatic zones. For these reasons, a compilation of climatological data of particular importance to tree growth has been made by the Alaska Forest Research Center and is presented in this paper with a brief discussion of the general climate and tree growth of the region.1/

THE REGION AND CLIMATE

Southeast Alaska includes a large group of coastwise islands and a narrow strip along the mainland lying between the northern part of British Columbia and the Pacific Ocean. The topography is rough and mountainous, and is cut by numerous inland waterways. The southern end of this area is in Latitude 55° N. and the northern end is almost at 60° N. latitude. This region is in approximately the same latitude as the British Isles and the southern part of Norway and Sweden.

In Southeast Alaska the forest is primarily a mixture of western hemlock (Tsuga heterophylla (Raf.) Sarg.) and Sitka spruce. Western redcedar (Thuja plicata Donn.) and Alaska yellow cedar (Chamaecyparis nootkatensis /D. Don/Spach) are also encountered and locally may be abundant. In passing northward and westward the details of forest composition change; certain species disappear and the relative abundance of others become altered. For example, western redcedar is not found north of Petersburg. On cold, wet sites, scrubby stands and muskegs are found.

The climate of Southeast Alaska is generally cool and moist with a relatively narrow range between summer and winter temperature. The climate of the area is governed largely by the "Aleutian Low", from which offshoots move southeastward bringing an onshore flow of relatively warm moisture-laden air. (1) The flow of the moisture-laden air across this mountainous region results in heavy precipitation which is well distributed throughout the growing season. There is no pronounced summer drought.

1/ Grateful acknowledgement is made to Claude V. Brown, Officer in Charge, U. S. Weather Bureau Office, Juneau, Alaska, for advice and assistance, and to Robert F. Dale, Climatologist, U. S. Weather Bureau, Anchorage, Alaska, for furnishing summarized data from his files as well as reviewing the manuscript.

The extreme northern portion and along the mainland is influenced to a considerable extent by an area of high-pressure overlying the Yukon Valley and Canada; weather conditions being more continental than maritime. In this area there is a greater range in summer and winter temperatures than in other parts of the region. There is a marked reduction in precipitation. In winter strong northerly winds often blow down Lynn Canal and the larger river valleys. The influence of the flow of cold air down Lynn Canal from the Interior is shown by the position of the isotherms in Figure 1.[2/] The climate of the outer islands is influenced to a marked extent by the Pacific Ocean. The prevalence of sea fog probably tends to keep summer temperatures down. In the winter the oceanic influence tends to keep temperatures higher than that of stations lying nearer the mainland.

As may be expected in a mountainous region, there are great variations in climate within short distances. For example, total precipitation at the Juneau Airport, which lies approximately eight miles northwest of the City of Juneau, is 65 percent of the total precipitation of Juneau. Yearly amounts in Juneau have reached as high as 119.48 inches, and at the Airport, 64.06 inches. The average frost-free season at the Airport extends from May 4 to September 28, a total of 146 days. In Juneau this period extends from April 22 to October 21, a total of 181 days. (2)

This variation in climate and wide spacing of climatological stations make it possible to present only a general, rather than a detailed, description of the climatic factors. A number of the stations are located on isolated rocks and islets. Temperatures at such stations vary somewhat from those of nearby stations because of the influence of the surrounding water. Adjustments in position of isothermal lines were made for such stations. All stations are at, or near, sea level. Higher elevations tend to be colder. As a general rule the cooling of ascending free air is about 1° Fahrenheit for each 300 feet of elevation. Other factors such as aspect, slope, and relation of drainage to storm direction cause wide variations in local climate.

CLIMATIC FACTORS MOST CRITICAL TO TREE GROWTH

There is considerable difference of opinion as to which climatic factors are most vital to tree growth. Most authorities agree that the factor which may be important or limiting for one locality or species may be unimportant for other localities or species. (7)

Amount and distribution of precipitation and length of growing season are of special consequence. Average summer temperatures are of vital importance in the ultimate growth and development of a forest stand. Isaac (7) states that both maximum and minimum temperatures are of great significance to seedling establishment and growth. The values of these factors in Southeast Alaska are presented and discussed in some detail below.

2/ Lack of climatological stations along the mainland prevents the accurate plotting of isotherms; the general trend is indicated by dashed lines in Figure 1.

1. Precipitation

Data on precipitation are presented in Table 3 and Figure 3. Precipitation is heavy and well-distributed through the growing season. It is probable that it exceeds that necessary for optimum tree growth. The combination of high rainfall and relatively low potential evapotranspiration results in a water surplus. (10) One direct result of the heavy precipitation is in making soil drainage most critical in affecting productivity of the site for tree growth. Half-bog soils predominate where drainage is retarded. Muskegs (peat bogs) usually occur where drainage is impeded. Preliminary studies by the Alaska Forest Research Center indicate that the most productive sites occur on well-drained soils. Gessel (5) in a study of soil characteristics and site for Douglas-fir in northwest Washington found that after an optimum is reached site index tended to decrease with increasing rainfall. The heavy precipitation and number of cloudy days in Southeast Alaska also results in relatively low soil temperatures.

2. Mean temperature during growing season

Average summer temperatures are of vital importance in ultimate growth and development of forest stands. Toumey and Korstian (11) state that lower temperatures over a longer period during the growing season are not equivalent to higher temperatures of shorter duration. Mean temperature during the period May through September, as well as mean monthly temperatures for this period, are presented in Table 2. For the period May through September, monthly mean temperatures exceed 42° F. Most authorities agree that the 40-42° F. range is near minimum for initiation of plant growth (8) (9). Isotherms of mean temperatures for this period are shown in Figure 2. It can be seen from this figure that mean temperature for the period May to September generally decreases northward. The area of higher temperature in Lynn Canal is probably due to the influence of the continental air mass discussed above.

In Southeast Alaska the relatively low temperatures during the growing season may be a limiting factor in tree growth and development. Studies made by the Alaska Forest Research Center provide some indication of this. A classification of climax forests has been developed in which Class I represents the highest volume or most productive stands, while Class V represents scrub or non-merchantable stands (6). As a part of this study the frequency of occurrence of the productivity classes by aspect was determined. The results are shown in Table 1.

The high proportion of Class I stands occurring on south slopes, and the high proportion of Class V (scrub stands) occurring on north slopes, is a strong indication that low temperature might be a limiting factor. South slopes may receive nearly 50 percent more heat than north slopes of the same inclination. (4)

Table 1.—Frequency of occurrence of climax forest productivity class by aspect

Aspect	Productivity Class V	IV	III	II	I
	Percentage each class by aspect				
North	75	44	23	21	7
East	17	11	31	15	35
South	8	17	20	33	42
West	—	28	26	31	16

Another indication that low temperature may be a limiting factor is an apparent decrease in site index in the northern portion of Southeast Alaska.[3] Site index, based on average height of dominant trees at 100 years, of a number of growth and yield plots was computed for each unit. The difference in average site index as shown below between northern and southern portion was found significant at the 5 percent level.

	Number of plots	Average site-index
North	14	104
South	19	116

The southern part of Southeast Alaska apparently marks a boundary of a climatic or plant zone. It is of interest to note that the northern coastal limits of four tree species, western redcedar, Pacific yew (Taxus brevifolia Nutt.), Pacific silver fir (Abies amabilis [Dougl.] Forbes), and bigleaf maple (Acer macrophyllum Pursh) as well as several plants (salal, Gaultheria shallon, and swordfern, Polystichum munitum) prominent in the flora of the Pacific Northwest, are reached at or near the British Columbia-Alaska boundary, Figure 3. The limits of Pacific silver fir and Pacific yew lie within an area where the mean temperature during the growing season is probably greater than 55° F. Alpine fir (Abies lasiocarpa [Hook] Nutt) is found in the southern portion of Southeast Alaska generally within the 55° F. isotherm and reappears in the northern section near Skagway, which is near the 55° F. isotherm. Bigleaf maple reaches its northern limits at the British Columbia-Alaska boundary.

3. Frost-free days

Most forest trees in temperate climates start growth before the last frost in the spring and stop growth before the first frost in the fall.(7) While growing season does not coincide with the frost-free period, it usually constitutes the best measure of the length of growing season. Isaac (7) states that in two areas of similar rainfall and soil conditions annual growth is usually proportional to the length of the frost-free period. The length of this period becomes particularly important in

3/ For the purpose of sampling timber volume and in conducting studies of tree growth, southeastern Alaska has been divided into a South and North Unit, Figure 2.

development of seed collection zones as adaptation to length of growing season may become so fixed as to be classed as a hereditary characteristic. (3) (7).

The average number of frost-free days at various climatological stations is given in Table 2. It will be noted that this value is subject to considerable variation, probably due to the fact that frost formation is affected by topography, air, drainage, and other local factors.

4. Mean temperature during the three coldest months

Normal mean temperature during the period December - February is given in Table 2 and also in Figure 1. While mean temperature during the coldest season of the year may have little direct effect on tree growth, this factor may be important from the standpoint of the development of local races or strains of winter-hardy trees.

SUMMARY

Increased interest in the forests of Southeast Alaska and silvical studies conducted by the Alaska Forest Research Center made it necessary to compile information on climatic factors considered most vital for tree growth. These factors include amount and distribution of precipitation; mean temperature of growing period; mean temperature for the coldest period of the year; and number of frost-free days. These data have been summarized from Weather Bureau records and are presented in Tables 2 and 3.

Rainfall in Southeast Alaska is probably excessive for optimum tree growth as the high rainfall tends to cause an excess of groundwater. Best sites here are found on well-drained areas. Low temperatures during the growing season may be a limiting factor for tree growth as shown by the preponderence of high site classes on south slopes and decrease of average site index in the northern portion.

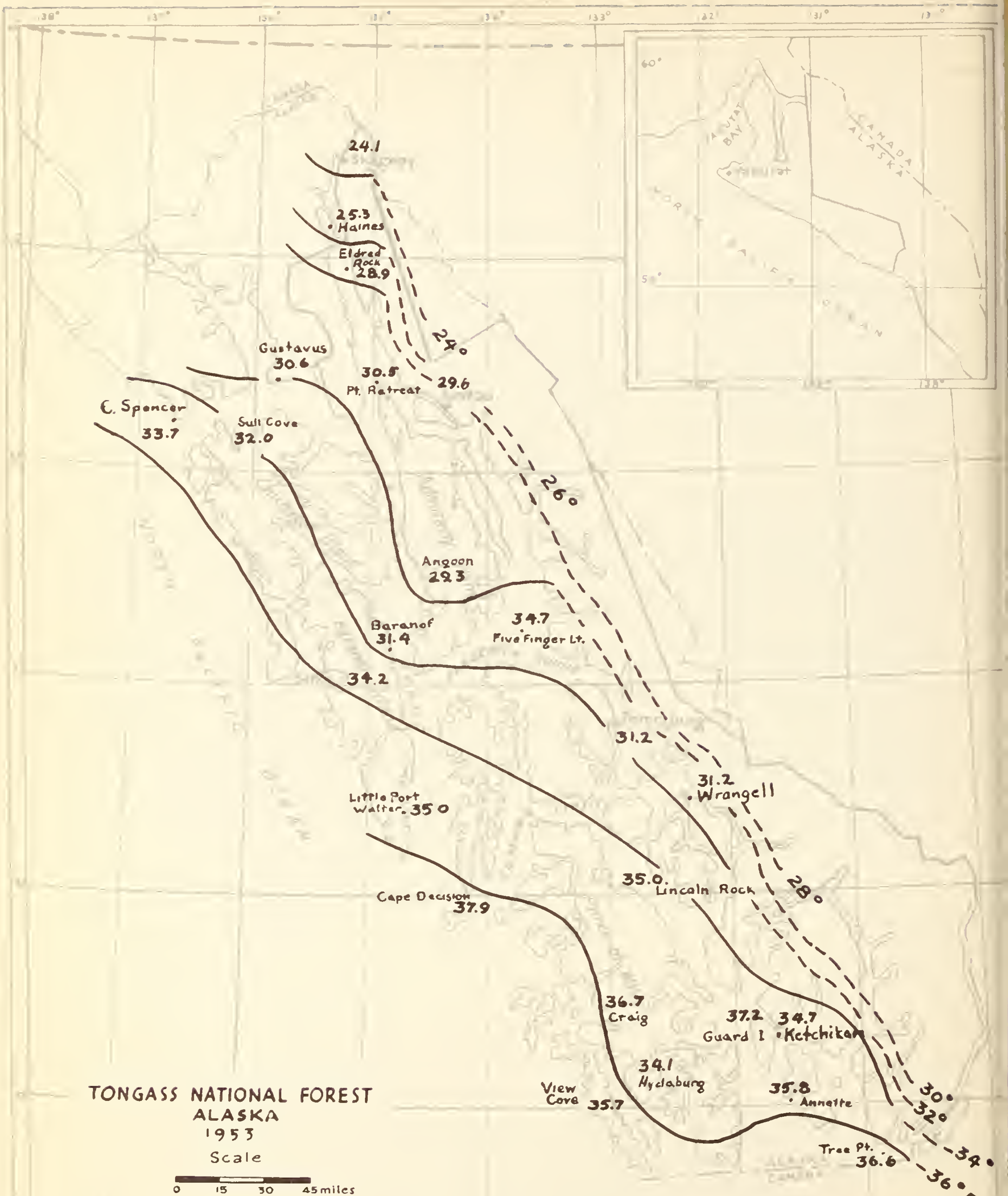

Fig. 1. Mean temperature isotherms for Dec., Jan., Feb., Degrees Fahrenheit.

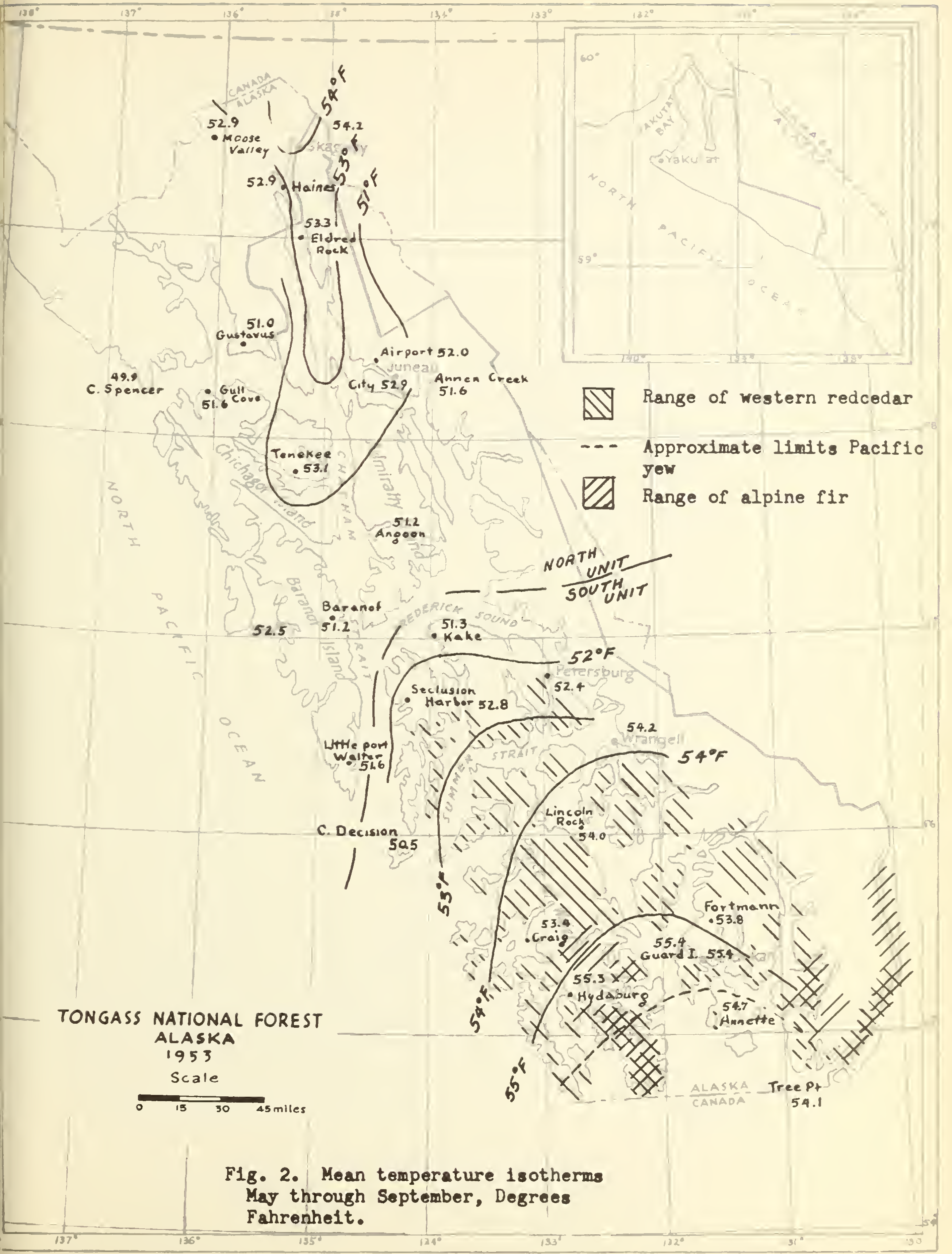

Fig. 2. Mean temperature isotherms May through September, Degrees Fahrenheit.

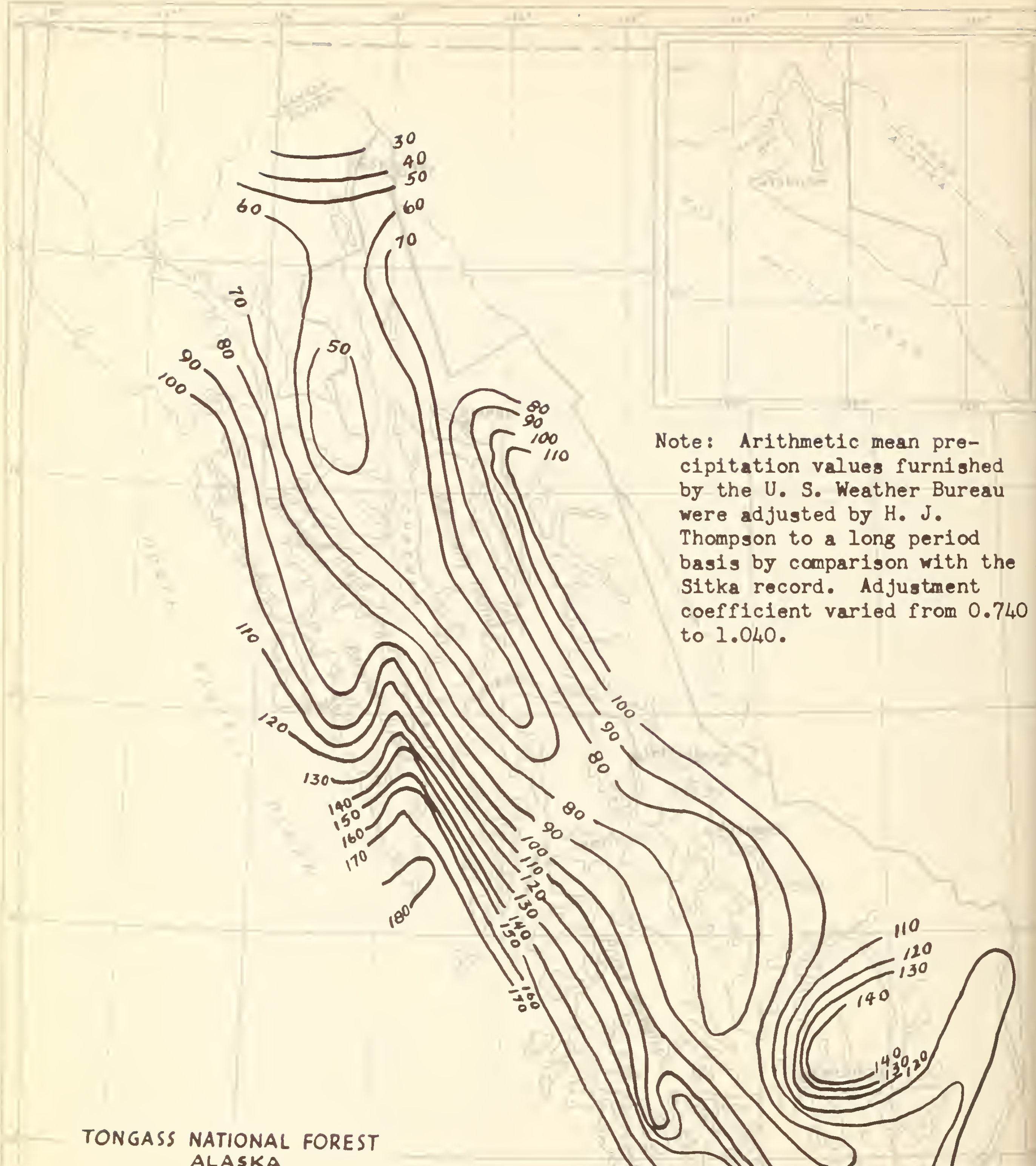

Fig. 3. Isohyetal map based on sea level conditions. From Water Powers of Southeast Alaska, 1947. Federal Power Commission and U. S. Forest Service.

Table 2.--Temperature data, Southeast Alaska

Stations	Years record	Elevation	Mean Temperature May	June	July	Aug.	Sept.	May-Sept.	Annual	Absolute Max.	Min.	Av.Len. Grow. Season
*Angoon	12	35	46.6	51.5	54.1	54.2	49.6	51.2	40.9	84 2/	0	155
*Annette	12	110	49.6	54.5	57.5	58.2	53.7	54.7	45.6	90	-4	197
*Annex Ck.			47.3	53.2	54.9	53.7	49.0	51.6	39.9	34	-18	151
*Baranof	15	20	45.0	51.7	54.5	54.2	50.4	51.2	41.9	78	-7	164
*C.Decision	10	39	45.2	50.1	52.8	53.2	51.3	50.5	44.1	80	0	221
*C.Spencer	15	81	45.2	49.1	52.3	52.6	50.3	49.9	42.4	78	-1	197
*Craig	14	13	48.0	52.8	55.9	56.5	53.7	53.4	45.0	86	-2	
*Eldred Rock	8	55	48.0	55.8	56.5	55.9	50.3	53.3	42.1	82	-14	
Fortmann Hatchery	18	—	47.3	53.7	57.9	57.7	52.2	53.8	42.7	93	-23	
*Guard Id.	11	20	50.0	55.6	58.7	58.9	53.8	55.4	46.0	81	3	221
Gull Cove	11	18	46.5	51.8	53.7	53.6	49.6	51.0	41.6	80	0	
*Gustavus	16	22	46.5	52.2	55.2	54.0	50.0	51.6	41.1	83	-20	104
*Haines	28	257	48.5	52.3	57.4	55.9	50.2	52.9	40.5	99	-36	
Hydaburg	9	25	48.7	55.5	58.2	59.6	54.3	55.3	45.9	—	—	
*Juneau												
City	56	72	47.5	54.2	56.2	55.7	50.9	52.9	42.2	89	-15	177
Airport	10		47.2	53.7	55.5	54.0	49.5	52.0	40.3	85	-21	146
Kake	9	8	45.4	52.0	54.1	55.2	49.6	51.3	42.1	88	-4	
*Ketchikan	40	15	50.1	55.2	58.4	58.8	54.7	55.4	45.4	96	-8	170
*Lincoln Rk.	9	25	48.5	53.9	56.5	57.5	53.4	54.0	45.1	85	-3	220
*L.Port Walter	16	14	45.7	51.4	54.9	54.9	51.2	51.6	43.3	77	3	184
*Moose Val.			46.5	54.9	58.4	55.6	48.9	52.9	35.7	93	-14	89
*Petersburg	21	100	48.0	53.9	55.5	54.9	49.9	52.4	42.4	84	-9	138
Secl. Hbr.	7	20	47.6	53.7	56.5	54.9	51.3	52.8	43.8	92	-2	
*Sitka	69	67	46.7	52.2	55.1	56.2	52.4	52.5	43.8	86	-5	155
*Skagway	34	—	48.7	55.5	57.3	59.4	50.1	54.2	40.5	92	-22	109
Tenakee	7	19	47.9	53.7	55.7	56.3	52.0	53.1	42.4	83	-4	
*Tree Pt.	19	36	49.2	53.9	56.6	57.5	53.4	54.1	46.0	75	-7	147
*Wrangell	36	37	49.7	55.5	57.3	56.7	52.0	54.2	43.7	84	0	165
*Yakutat 1/	29	28	43.8	49.9	53.5	53.1	48.9	49.8	39.4	80	-22	

* Stations now active. Data thru 1952.

1/ Not shown on map. Located at Latitude 59°31' N. Longitude 139°40' W.

2/ Extremes are a function of length of record as well as a climatic statistic; therefore, data are not directly comparable between stations with different lengths of record.

Table 3.--Meteorological stations showing years of records, annual precipitation in inches, and monthly percentages

Station	Years record	Annual Precipitation: Sum of monthly means	Annual Precipitation: Climatic year means	Annual Precipitation: Adjusted for Iso-hyetal map	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Baranof	3.0	173.88	164.40	120	9.8	7.2	8.1	7.9	5.8	2.4	2.8	6.4	6.4	15.2	13.7	14.3
Cape Spencer	3.1	118.86	118.30	86	8.6	6.7	5.1	4.1	5.7	5.4	7.7	8.6	15.0	12.8	11.6	8.7
Craig	2.9	114.94	109.98	111	14.3	5.7	6.2	9.1	6.0	3.6	4.1	4.9	8.0	14.5	11.7	11.9
Fortman	23.2	147.75	148.12	149	8.3	8.0	7.9	8.1	5.6	3.9	4.8	5.7	9.2	13.5	14.0	11.0
Haines	15.5	57.38	57.82	52	9.8	8.7	8.1	5.8	3.4	2.7	3.2	4.3	8.6	18.2	14.3	12.9
Hyder	3.2	80.74	78.30	90	12.3	6.4	6.5	5.7	4.1	3.4	4.0	5.0	9.2	15.7	15.3	12.4
Juneau	46.5	84.04	82.72	82	8.6	6.8	6.5	6.5	6.2	4.7	6.1	8.9	12.2	13.5	10.9	9.1
Kake	10.9	54.19	56.19	51	9.6	9.9	5.5	7.1	5.6	4.0	4.6	8.0	9.6	13.5	12.4	10.2
Kasaan	13.4	84.82	84.64	85	10.6	8.4	7.1	7.7	6.7	4.5	4.3	5.3	7.5	12.3	12.6	13.0
Ketchikan	28.8	151.87	152.19	145	9.2	7.6	7.9	7.3	5.5	4.3	5.4	7.6	8.1	13.4	13.1	10.6
Killisnoo	31.8	50.89	55.74	51	9.4	7.8	5.7	5.8	5.0	4.1	6.4	8.0	12.5	14.5	11.1	9.7
Klukwan	11.4	21.49	21.30	22	7.6	6.5	5.6	2.9	2.7	2.8	6.6	6.8	16.3	16.1	14.6	11.5
Little Port Walter	3.4	249.21	248.10	180	9.4	8.3	6.5	5.4	5.4	3.1	6.2	5.0	9.6	14.9	14.7	11.5
Metlakatla	2.8	112.16	112.90	81	11.2	9.1	6.8	6.1	6.5	2.8	5.9	7.2	7.3	14.1	10.0	13.0
Petersburg	9.6	108.49	114.48	95	8.3	8.9	6.5	6.1	5.4	4.1	4.9	6.7	11.1	14.7	12.3	11.0
Seclusion Harbor	7.1	113.33	111.45	101	10.8	8.0	6.8	6.1	4.9	3.2	4.1	6.8	7.8	16.3	13.9	11.3
Sitka	71.1	86.00	85.97	86	9.0	7.5	6.6	6.4	4.7	3.9	4.9	8.4	11.9	14.8	11.4	10.5
Skagway	30.1	26.91	27.04	26	7.6	5.4	4.9	5.4	3.3	3.4	5.4	7.1	13.1	18.6	15.4	10.4
Sitka a/	6.5	107.03	109.05	86	9.1	9.8	9.4	5.8	4.6	3.3	4.9	6.5	11.7	12.6	12.8	9.5
Strawberry Pt. (near Gustavus)	2.6	54.02	52.94	49	13.3	6.9	4.9	6.9	5.8	2.5	7.0	6.0	10.2	12.6	14.2	9.7
Tree Point	10.2	100.85	99.51	91	10.9	7.4	6.6	6.7	5.5	5.5	5.5	5.6	8.7	12.8	13.6	11.2
View Cove	7.8	160.87	155.57	142	11.8	7.7	7.4	7.4	5.9	4.0	4.1	4.6	8.0	12.4	14.2	12.5
Wrangell	21.9	84.28	84.96	74	9.3	8.6	6.4	5.9	5.2	4.3	5.4	6.6	10.1	13.9	14.1	10.2
Yakutat b/	19.0	131.39	127.32	118	8.3	7.4	6.9	6.0	6.0	3.2	6.4	8.2	11.4	13.5	12.9	9.8

a/ The exact location and elevation of the rain gage is not known for the period of April 1881 to Sept. 1887.
b/ This station is not plotted upon the map.

From: Water Powers, Southeast Alaska, 1947

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